

Relationships between Fire and Bird Density in Coastal Scrub and Slash Pine Flatwoods in Florida

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ABSTRACT.—Bird densities within coastal scrub and slash pine flatwoods were compared with time since fire, mean shrub height, number of snags and percent burn. Most shrub-dwelling birds preferred older stands (>10 yr since last fire) with taller shrubs, or intermediate stands (4 yr since last fire) than recently burned stands (1–2 yr since last fire). Five species were negatively correlated with percent burn in stands burned 1–2 yr previously. The downy woodpecker was most abundant in recently burned areas. Densities of three species of woodpeckers and the northern bobwhite were positively correlated with snag density. The results suggest that extensive burns occurring every 4 yr or less are likely to have a negative influence on shrub-dwelling birds that are a natural component of these coastal communities.

INTRODUCTION

Early avian studies in Florida pinelands involved areas where shrubs were a minor component of the community because of frequent natural fires (Emlen, 1970; Engstrom *et al.*, 1984; Robertson, 1955). Fire-related changes have little influence on bird communities in these habitats because the habitat changes are of short duration and frequent fire is a normal feature (Emlen, 1970). However, where fires have been suppressed, dramatic changes occur in vegetation and avian community structure as open pinelands are replaced by closed forests (Engstrom *et al.*, 1984).

Some natural pinelands in Florida have a dense shrub layer, but there are few studies of the effects of fire on bird communities in these areas (or other scrub habitats). Some slash pine (*Pinus elliotii*) areas have dense saw palmetto (*Serenoa repens*) or other shrubs, even where frequent fires occur (Harper, 1921). Sand pine (*Pinus clausa*) scrub has a closed canopy and scrubby understory with natural fires occurring every 20–40 yr or longer; habitat changes associated with burning are dramatic and of long duration (Austin, 1976). Scrubby flatwoods is a predominately evergreen, xeromorphic habitat with an abundance of scrub oak shrubs in the understory and an open canopy of pine (Abrahamson, 1984). Natural fire frequency in scrubby flatwoods is intermediate between sand pine scrub and pinelands that lack a dense shrub layer (Abrahamson, 1984). Oak/palmetto scrub is structurally similar to scrubby flatwoods except there are fewer openings in the shrub layer in oak/palmetto scrub, there is no pine overstory (Breininger and Schmalzer, 1990) and saw palmettos may dominate the shrub layer on poorly drained sites (Breininger *et al.*, 1988).

Vegetation changes associated with fire in oak/palmetto scrub on the Kennedy Space Center (KSC) are similar to those changes in scrubby flatwoods (Abrahamson, 1984; Schmalzer and Hinkle, 1987). Differences have been observed between bird communities of two scrubby flatwoods sites, one which was unburned for 3 yr and the other which had not burned for 30 yr (Woollenden, 1969, 1970). Bird community composition in an oak/palmetto scrub was altered for at least 6 mo in plots where the vegetation was almost completely burned (Breininger and Schmalzer, 1990); little change in bird community composition occurred in plots where most of the vegetation was unburned.

In 1985–1986 a 1-yr study was conducted to determine how the avian community varies

with habitat characteristics in scrub and slash pine flatwoods on the KSC. This area is important because it provides habitat for one of the three largest populations of the Florida scrub jay (*Aphelocoma coerulescens coerulescens*), which is federally listed as a threatened species (Breininger, 1989; Cox, 1984). This paper focuses on differences in these avian communities associated with fire, particularly time since fire, shrub height, percent burn and the number of snags.

STUDY AREA AND METHODS

The KSC is located on 57,000 ha of the E-central Florida coast in Brevard County. It includes Merritt Island National Wildlife Refuge, which is comprised of lands and waters not currently being used for the space program and is managed by the U.S. Fish and Wildlife Service (USFWS). Topography is dominated by a series of ridges and swales with 6981 ha of scrub and 3558 ha of slash pine flatwoods being the major upland types. Both have a nearly continuous shrub layer that is dominated by scrub oaks (*Quercus myrtifolia* and *Q. geminata*) on the drier sites and saw palmetto on the wetter sites; dominance is mixed on most sites. Areas mapped as slash pine flatwoods differ from scrub by having an open canopy of slash pine (Breininger *et al.*, 1988; Schmalzer and Hinkle, 1987). Areas mapped as scrub have a few scattered slash pines and cabbage palms (*Sabal palmetto*). A general policy of fire suppression was in effect between 1963 and 1975. After that time the USFWS began a limited prescribed fire program. A more extensive program was instituted in 1981, providing a 3-yr burning cycle for most areas of scrub and slash pine.

The variable circular plot (VCP) method (Reynolds *et al.*, 1980) was used to survey birds (English and scientific names in Appendix) from February 1985 to February 1986 (Breininger, 1989, 1990). Thirty-eight stations occurred in areas where the vegetation was mapped as scrub and 35 occurred in areas mapped as slash pine flatwoods. Groups of eight stations were assigned to a route arranged in a roughly elliptical pattern. Because this study was part of a larger study encompassing many habitat types, some routes included stations that were not in scrub or slash pine flatwoods. Stations were at least 200 m apart. Each route was surveyed once every 6 wk throughout the study.

The VCP method requires the determination of an effective detection radius (R) which represents the distance from the observer where it is assumed that detectability of all birds approaches 100%. In this study, it was believed that the R value might vary among the stations because of differing vegetation characteristics, so the stations were divided into visibility classes. Birds are visible at farther distances in recently burned areas because of a lower shrub layer (<1 m) than in unburned areas. Disturbed habitats are areas of scrub and slash pine flatwoods that were once cleared but have since revegetated (Breininger and Schmalzer, 1990). In disturbed areas, birds are readily seen near the observer due to an abundance of openings, but visibility is poor at greater distances (>50 m) because of a high shrub layer (Breininger and Schmalzer, 1990).

Stations were assigned to one of the three following visibility classes, based on time since the last fire and the occurrence of past (>10 yr) mechanical clearing to the shrub layer: (1) recently burned (<4 yr since fire), (2) unburned (>10 yr since fire), and (3) disturbed. An R value was determined for each visibility class by estimating the inflection point of a graph of the number of birds per area per band counted using 10-m concentric bands (Reynolds *et al.*, 1980). Values of R were calculated by combining the data for the entire year. Seasonal R values were found to be equal to each other and occasionally higher than the yearly R values (Breininger and Schmalzer, 1990). The lowest R value among the three visibility classes was used to estimate the density for each species at each station; detectability should approach 100% for all stations at that distance. This method for determining R was used

for ground and shrub-dwelling birds. Values of R for tree-dwelling birds were similarly determined except that data were combined for all stations among the visibility classes. Tree-dwelling species were easily observed regardless of understory characteristics. Values of R ranged from 30 m for a shrub-dwelling species to 90 m for a tree-dwelling species.

Density of each species was calculated by multiplying the number of singing males within R by two, unless the total count of both males and females within R was greater, in which case the total number of sightings was used (DeSante, 1986). Birds/ha were calculated for each station by summing the total number seen within R , dividing by 8 (the number of samples), dividing by the area within R , and multiplying by 10,000. Densities were determined for all ground and shrub-dwelling species with >24 sightings for each of the visibility classes (Burnham *et al.*, 1980), and for tree-dwelling species with >24 sightings for all stations combined.

The number of years since the last fire was determined for each station from USFWS records and historical aerial imagery. Each station, including those that were mechanically disturbed, was reclassified according to a time-since-fire category of 1 yr, 2 yr, 4 yr, or over 10 yr. No stations occurred that were between 4 and 10 yr postfire. Eight stations that burned during the study were excluded from analysis. Mean bird densities were calculated for each burn class. One-way ANOVA was run with density as the dependent variable and time-since-fire category as the independent variable. For species that showed a significant overall response, a Newman-Keuls multicomparison test was used to elucidate differences among categories. Differences due to habitat type were not tested because the focus of this study was on the general influence of fire. There is much variation among scrub and slash pine flatwood stands; in other studies we have subdivided this habitat into 13 habitat types based on soils, mechanical disturbance, fire effects and vegetation composition.

Mean shrub height was determined for all stations. Percent burn was determined for 16 stations that had burned within 2 yr of the beginning of the study; the percent burn was zero for the other stations. Percent burn and mean shrub height were measured by a modification of the point intercept method (Breininger *et al.*, 1988; Hayes *et al.*, 1981; Mueller-Dombois and Ellenberg, 1974). Eight lines of four points each, 10 m apart, originated at a 45° angle from the center of each station. At every point, the presence or absence of recent fire was noted and the height of the nearest shrub was measured. The number of points showing the presence of fire divided by the total number of points gave an estimate of the percent of the area burned for the station. Shrub height measurements from each point were averaged to derive an estimate of mean shrub height for the station. The number of snags within a 40-m radius surrounding the center point of the station was counted and converted to snags/ha.

Densities of birds were compared with mean shrub height, the percent burned and snag density for each station using product-moment correlation analysis. Only those species with P values ≤ 0.05 were considered significant.

RESULTS

Densities of the great crested flycatcher, blue jay, Florida scrub jay and yellow-rumped warbler showed no significant relationship to fire. The Carolina wren and white-eyed vireo had significantly higher densities in areas that had not burned for more than 10 yr than in recently burned areas (Table 1). The common yellowthroat and rufous-sided towhee preferred stations burned 4 yr previously. No shrub species had its highest density within the 1-yr-since-fire class. Four species had significant ANOVA results, but could not be separated among burn classes by the Newman-Keuls test because of inadequate sample size. Densities of some bird species were significantly correlated with mean shrub height, percent burn,

TABLE 1.—Densities of species with significant differences in response to time since fire in scrub and slash pine flatwoods

Species	ANOVA (n = 65)		Newman-Keuls	
	F	P	\bar{x} density (no./ha) ^a	Years since fire ^b
Downy woodpecker	3.6	0.02	0.2 A	2
			0.1 AB	1
			<0.1 B	4
			<0.1 B	10
Carolina wren	12.0	0.0001	1.3 A	10
			0.7 B	2
			0.6 B	4
			0.4 B	1
Gray catbird	4.1	0.01	0.6 A	10
			0.4 AB	4
			0.2 B	2
			0.1 B	1
White-eyed vireo	13.2	0.0001	1.2 A	10
			0.2 B	1
			0.2 B	2
			<0.1 B	4
Common yellowthroat	10.4	0.0001	1.7 A	4
			0.9 B	1
			0.6 BC	2
			0.3 C	10
Northern cardinal	4.5	0.007	0.5 A	10
			0.2 AB	1
			0.1 B	2
			<0.1 B	4
Rufous-sided towhee	4.4	0.007	4.5 A	4
			3.3 B	2
			2.6 B	10
			2.3 B	1

^a Densities with different letters are significantly different between years-since-fire categories

^b Numbers of stations for the years-since-fire categories are 1 year since fire = 16, 2 years since fire = 16, 4 yrs since fire = 9, >10 yr since fire = 24

and the number of snags (Table 2). Northern bobwhite, red-bellied woodpecker and northern flicker densities were correlated with the number of snags, but these species did not show significant responses to time since fire.

Time since fire was correlated with snag density ($r = -0.23$, $P = 0.047$) and shrub height ($r = 0.70$, $P = 0.0001$). Shrub height was negatively correlated with snag density ($r = -0.24$, $P = 0.037$).

DISCUSSION

Birds of scrub and slash pine flatwoods are undoubtedly influenced by habitat factors other than those affected by fire. However, understanding the influence of fire is especially

TABLE 2.—Correlation coefficients between bird densities and percent burn, shrub height, and snag density

Species	Habitat parameters		
	Percent burn ^a	Mean shrub height	Snag density
Carolina wren	-0.47 (P < 0.01)	0.52 (P < 0.01)	NS ^b
White-eyed vireo	-0.47 (P < 0.01)	0.46 (P < 0.01)	-0.27 (P = 0.02)
Northern cardinal	-0.31 (P < 0.01)	0.36 (P < 0.01)	NS
Gray catbird	-0.39 (P < 0.01)	0.23 (P = 0.05)	-0.24 (P = 0.04)
Rufous-sided towhee	NS	-0.29 (P = 0.01)	NS
Common yellowthroat	NS	-0.44 (P < 0.01)	NS
Northern bobwhite	NS	NS	0.24 (P = 0.04)
Northern flicker	NS	-0.28 (P = 0.02)	0.58 (P < 0.01)
Red-bellied woodpecker	0.28 (P = 0.01)	-0.26 (P = 0.02)	0.43 (P < 0.01)
Downy woodpecker	0.32 (P < 0.01)	NS	0.77 (P < 0.01)

^a Percent of area burned within 2 years of the beginning of the study

^b NS = P > 0.05

important because it is the primary tool used to manage these habitats. Two shrub-dwelling species preferred stands that had not burned for more than 10 yr and two preferred intermediate conditions. No shrub-dwelling birds preferred the most recently burned (≤ 2 yr) areas. Avian species that preferred unburned areas, such as the Carolina wren, gray catbird, white-eyed vireo and northern cardinal, are abundant within broad-leaved woodlands on KSC (Breininger, 1990). Most common land birds of S Florida are forest-edge species. Breeding bird densities are highest in shrub stages and decline as succession proceeds towards a closed forest (Robertson, 1955). Higher densities of birds occur in scrub and slash pine flatwoods on KSC than in broad-leaved forests, mainly because the most abundant bird in scrub and slash pine flatwoods, the rufous-sided towhee, is not found in woodlands except as an occasional visitor (Breininger and Schmalzer, 1990; Breininger, 1990).

The abundance of snags in recently burned areas probably accounts for the higher densities of woodpeckers found there. Downy woodpeckers, unlike red-bellied woodpeckers and northern flickers, are uncommon in hammocks and swamps on KSC (Breininger, 1990); recently burned areas with slash pine trees and snags appear to be necessary for maintaining populations of downy woodpeckers. However, repeated burning can destroy snags (Wood and Niles, 1978), so the relationships between fire and woodpecker densities may change with time.

Unlike many other Florida pine communities, ground-dwelling birds were scarce in scrub and slash pine on KSC. Numbers of ground-dwelling birds often increase after fires in S Florida pinelands (Robertson, 1955). Northern bobwhites may have preferred areas with snags in this study because snags are associated with bare ground, which is important to the northern bobwhite (Landers, 1981). Bare areas are rare in most undisturbed scrub and slash pine flatwoods on KSC (Breininger, 1981; Breininger *et al.*, 1988; Schmalzer and Hinkle, 1987).

The Florida scrub jay did not respond to fire effects in this study. They occupy territories much larger than the areas sampled by the stations (Breininger and Smith, 1989; Woolfenden and Fitzpatrick, 1984), which could have masked significant relationships with fire (Best and Stauffer, 1984). Elsewhere in Florida, fire suppression policies have resulted in areas becoming unsuitable for scrub jays (Cox, 1984; Woolfenden and Fitzpatrick, 1984; Westcott,

1970). Fires that occur too frequently can kill oaks (Guerin, 1988; Robbins and Myers, 1989) which Florida scrub jays require for cover, acorns and nesting (Cox, 1984; Westcott, 1970; Woolfenden and Fitzpatrick, 1984; Breininger *et al.*, 1991).

The shrub layer in shrub and slash pine flatwoods on KSC has taken more than 7 yr to reach an average scrub height of 1.5 m (the optimal height for scrub jays) after recent fires (Breininger *et al.*, 1988; Schmalzer and Hinkle, 1987). Studies of vegetation regrowth after fire on KSC have occurred in areas that had burned once or twice since the end of a long period of fire suppression (Breininger and Schmalzer, 1990; Schmalzer and Hinkle, 1987, 1991). Repeated fires may slow regrowth as carbohydrate reserves diminish (Davidson and Bratton, 1986). Correlations between densities of shrub-dwelling birds and mean shrub height suggest that these populations would decline under a frequent fire regime.

Large slash pines are important for bald eagles on KSC because they provide nest sites. Many slash pine trees have been killed in recent fires, partly because of high fuel levels that accumulate during long periods without fire. Little information is available on regeneration of natural stands of slash pine (Hebb and Clewell, 1976). Seedlings and saplings are unable to survive many surface fires (McCulley, 1950), but pine stands need occasional fires because slash pine seedlings require bare soil for establishment (Fowells, 1965).

This study has shown that burning extensive areas of scrub and slash pine flatwoods as frequently as every 7 yr will have a negative influence on several shrub-dwelling birds. Small, patchy burns, however, would have little effect on these species (Breininger and Schmalzer, 1990). Fire regimes appropriate for maintaining pine trees for populations of woodpeckers and bald eagles are unclear. It has been recommended that oak scrub should be burned every 8–20 yr at Archbold Biological Station (Highlands County) which is 133 km away from KSC (Fitzpatrick *et al.*, 1991). Further study is needed to determine a fire frequency that maintains native bird populations in oak/palmetto scrub and slash pine flatwoods on KSC where there is a natural shrub understory. Fire frequencies suitable for maintaining bird populations in Florida pinelands that have a sparse shrub layer (*e.g.*, Emlen, 1970) are not appropriate for scrub habitats.

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APPENDIX

English and scientific names of birds (American Ornithologists' Union 1983) sighted in scrub and slash pine habitats on Kennedy Space Center, Florida.

Bald eagle	<i>Haliaeetus leucocephalus</i>
Northern bobwhite	<i>Colinus virginianus</i>
Red-bellied woodpecker	<i>Melanerpes carolinus</i>
Downy woodpecker	<i>Picoides pubescens</i>
Northern flicker	<i>Colaptes auratus</i>
Great crested flycatcher	<i>Myiarchus crinitus</i>
Blue jay	<i>Cyanocitta cristata</i>
Florida scrub jay	<i>Aphelocoma c. coerulescens</i>
Carolina wren	<i>Thryothorus ludovicianus</i>
Gray catbird	<i>Dumetella carolinensis</i>
White-eyed vireo	<i>Vireo griseus</i>
Yellow-rumped warbler	<i>Dendroica coronata</i>
Common yellowthroat	<i>Geothlypis trichas</i>
Northern cardinal	<i>Cardinalis cardinalis</i>
Rufous-sided towhee	<i>Pipilo erythrophthalmus</i>